TRANSLATION

DESCRIPTION

DEVICE FOR ENABLING AN OBSERVER TO VERIFY THE ANGLE-DEPENDENT SCATTERING BEHAVIOR OF AN OBJECT

The present invention relates to a device for visual verification of the angle-dependent scattering properties of an object by an observer, the device having

a holder which is provided with a measuring window that can be brought into a predetermined position relative to the object as well as an observer window which allows viewing by the observer.

The invention relates further to an apparatus for the visual comparison of the angle-dependent scattering properties of a test object with a reference object by an observer as well as to an apparatus for the optical verification of flat objects.

From U.S. Patent 5,596,402 a device of a similar kind is known. In this device, the light supply sends two light ray beams under sharply different incident angles to the measuring window, namely, a first incident angle α_1 and a second incident angel α_2.

The patent is based upon the fact that the output angle β_1 of the first reflected beam is equal to the input angle α

thereof the output angle β_2 of the second reflected beam is equal to the incident angle α_2.

The first reflected beam β_1 is supplied directly to the observer via the behavior window. The second reflected beam β_2 is deflected via a mirror to the observation window and the observer. For the generation of two light beams which are incident at different angles, the light supply encompasses either two distinct lamps or a single lamp arranged behind a diffuser disk.

With the known device it is therefore not possible to observe an object with a goniodispersed property, i.e. its reflection and transmission properties at different output angles, because the incident angle is held substantially constant. This property or behavior is described in the present description also as the "scattering property". By comparison, the conventional device permits only an observation under two distinct output angles.

From EP 0 530 818, a color reflection device is known in which light beams radiating out at different angles are captured by three light guides and fed to photo sensors. Ahead of the light guide inlet orifices are switchable cover flaps or shutters so that invariably only one light guide at a time conducts light to the photo sensor which can then carry out a color analysis. Colors with angle-dependent reflection or transmission-scattering properties are used for example in the case of currencies or automotive lacquers. The angle-dependent properties arise for example as a result of constructive and destructive interference and give changing color and luminescence patterns with certain

light incidence and with different observation angles. For monitoring production and for verification purposes, especially with currency, it is desirable to provide a simple reliable apparatus for quick visual testing of these properties. The invention has as its goal to provide such an apparatus.

This aim is achieved with the aid of a device of the kind described at the outset which is characterized by

a light feed which is carried by a holder and is trained to direct substantially parallel light beams at a predetermined angle on the measuring window, and

a light guide device which is carried by the holder and captures light beams outputted from a point of the measurement window at a plurality of different angles and delivers them to the observation window in parallel or convergingly.

By "substantially parallel" a bundle of beams is to be understood in the present description as not diverging or converging more than ±10° from their setpoint beam direction, i.e. which diverges or converges by a maximum of about 20°. The device according to the invention enables simple, reliable and rapid visual verification of the angle-dependent reflection scattering properties or transmission scattering properties of an object in optionally many selected directions of their radiation and surface reflection radiation.

According to a first embodiment of the invention which serves to verify the angle dependent reflection scattering properties, the light feed and the light guide device are arranged on the same side of the measuring window. Alternatively, for

measurement of the transmission scattering properties, the light feed and the light guide device are arranged on different sides of the measuring window.

The observation window can be a display tube, an ocular, the surface of a lens or the like; according to a special variant of the invention, a viewing screen can be arranged in the observation window upon which the light beams impinge adjacent one another. Such a viewing screen can be equipped in an especially simple manner with scales, markings, reference scales or the like which permit in a simple manner the comparison of the imaged light beams.

The apparatus can be used for the measurement of reflection scattering properties or transmission scattering properties at predetermined wavelengths, in predetermined wavelength ranges, or over the total visible wavelength range. Advantageously, while light beams are trained on the measuring window so that the verification or testing covers the total visible wavelength region. In the case of wavelength converter inks, for example, UV converters, it will be self understood that also light outside the visible wavelength range can be trained upon the measuring window.

An especially advantageous embodiment of the invention is characterized in that the light feed has a light source, preferably a white light source and especially preferably a light emitting diode. Alternatively, the light feed also can collect ambient light and train it upon the measuring window, preferably where the

light feed is a light guide channel, especially a tube or a light waveguide.

The light guide device itself can be realized in different ways as well. According to a preferred variant of the invention, the light guide device can be a collecting lens, whereby the measuring window lies in the vicinity of the focal plane of the collecting lens. Such a light guide device captures light beams in an entire continuous region of different angles so that, stated otherwise, each angle can be determined and such that one color image differs rom the next, especially in the case of OVIs (Optically Variable Inks) with distinct stepwise varying properties. It is especially advantageous when the collecting lens is a cylindrical lens. In this case, the angle-dependent properties are determined only in the plane normal to the cylinder axis and the observation window can be viewed, for example, with both eyes.

It is especially advantageous when the collecting lens is a semicylinder, whereby the measuring window lies on or only a slight distance from the flat side of the semicylinder. In the first case, the lens can be placed directly on the object to be tested.

It is also possible to embed the light feed directly in the semicylinder which yields an especially compact line.

Instead of a lens, the light guide device can also be a cylindrical hollow mirror, whereby the measuring window lies in the vicinity of the hollow mirror. Alternatively, the light guide device can be formed from prisms or preferably from individual

light guides as is known per se from EP O 530 818 and which are respectively arranged to receive the mentioned reflective light beams at different angles. In other words each light guide collects an output light beam at a certain angle leaving the measuring windows and supplies it to the observation window. In this manner, the reflection scattering properties [behavior] or the transmission scattering properties [behavior] can be tested at certain discreet angles. It is especially advantageous when the ends of the light guides open adjacent one another in the observation window. The light guide locations thus supply colored light points which represent the reflection scattering properties or transmission scattering properties at certain angles and can be simply detected by a quick glance.

A further aspect of the invention resides in the provision of an apparatus for the visual comparison of the angle dependent scattering properties of a test object with a plurality of reference objects by an observer. This apparatus is characterized by at least two of the devices described according to the invention and which are connected together and have their observation windows lying adjacent one another. As a result, with a single glance, both observation windows can be encompassed and simply compared.

Preferably one of the units has a receiver for the reference object and the other unit an abutment for positioning the test object.

The reference object can remain permanently in one of the devices and the test object oriented relative to the reference object.

In a preferred embodiment of the apparatus, especially for flat bendable reference objects, the receiver can include a drum on which one or more reference objects can be fastened. When the drum is round, by rotation of the drum, one can switch between a plurality of reference objects. Independently of the form of the drum, when flat, bendable reference objects are used, a space saving can be obtained in that they can be wound on the drum.

Finally, another aspect of the invention involves the provision of an apparatus for the optical testing of flat objects which is characterized by a combination of:

a housing,

an emplacement surface carried by the housing and having at least one first and at least one second region for supporting an object and for sliding shifting of the object between the first and the second regions,

a device of the aforedescribed inventive kind which is carried by the housing and whose measuring window lies above the first region of the emplacement surface or coincides therewith, and

an infrared camera which is carried by the housing and is trained on the second region.

The apparatus according to the invention enables the testing of a number of optical criteria as are especially used as security features for securities with a rapid and simple kind of manipulation. The configuration with multiple test regions on one

and the same emplacement surface enables the object to be simply and conveniently shifted form one region to the next for corresponding testing without the need intervening for lifting of the object or its removal. Especially, the combination with an infrared camera enables the additional testing of optical criteria in the infrared range.

An especially advantageously embodiment of the apparatus is characterized by the use of an infrared camera in the form of a black and white CCD camera which has a blocking filter for the visible light range. It has been found that a simple commercial black white CCD camera has sufficient sensitivity in the infrared range which can be utilized upon corresponding filtration. This solution is especially inexpensive by comparison with the use of infrared image converter tubes.

The output of the infrared camera can be simply made available of a corresponding output terminal of the housing so that an external monitor can be connected to it.

Especially advantageous, however, is to provide a monitor which is supported by the housing and is connected to the output of the infrared camera so that the apparatus is largely freestanding.

The infrared testing can operate with ambient light which falls on the test object to the extent that the ambient light contains a sufficient infrared component. Especially advantageous, however, is to have the housing carry a second light source which is trained from above on the second region and which

has a significant radiation proportion in the infrared range and can be selectively turned on. In this manner the apparatus is largely independent from ambient light. It has been found that an especially inexpensive variant can utilize a glow filament lamp as the second light source.

The inventive concept of multicriteria testing can be made finer in that in a further preferred embodiment of the apparatus, the second region of the emplacement surface is light permeable and the housing carries a third light source which is oriented from below upon the second region and has a significant radiation component in the infrared range and can selectively be turned on. In this manner not only an infrared reflection property but also an infrared transmission property of the object can be monitored.

It is especially advantageous when the third light source additionally has a significant radiation component in the visible light range. In that case, a conventional transmitted light observation of the object with the free eye can be undertaken. An especially inexpensive solution is obtained here when a glow filament lamp is selected as the third light source.

In any case it is especially advantageous for the emplacement surface to have a third region for supporting the object and for sliding shifting of the latter between the first, the second and the third regions, whereby the housing carries a fourth light source which is trained onto the third region from above and has a significant radiation component in the ultraviolet range.

Thus as a further optical feature of the ultraviolet excitation properties of fluorescent printing inks as are widely used with securities can be verified.

Preferably the housing has a cover hood which is arranged above the emplacement surface and is formed with at least one lateral opening for access to the emplacement surface. Thus ambient light can be shielded from the test regions. It is especially advantageous for the third region to be spaced from the opening to reduce the escape of ultraviolet radiation form the opening.

According to a preferred feature of the invention, the emplacement surface can be equipped at a fourth region with an inductive sensor. Thereby the presence of inks with magnetic or metallic particles can be tested.

The invention will be described in greater detail based upon the embodiments shown in the drawing. In the drawing

FIG. 1 a first embodiment of a device schematically in section;

FIG. 2 a second embodiment of a device in section,

FIGS. 3 and 4 a first embodiment of an apparatus for comparing the scattering behavior in section and in a plan view,

FIG. 5 a second embodiment of such an apparatus in a perspective view,

FIG. 6 an apparatus for the optical verification in a schematic perspective view, and

FIG. 7 a filter curve of the infrared filter of the apparatus of FIG. 6.

The apparatus indicated generally with 1 in FIG. 1 encompasses a holding device 2 which is configured in the form of a wire frame and is applicable to the surface 3 of an article shown only partially. The holding device 2 defines on the surface 3 of the article 4 a measurement window 5 and, relative to the measurement window 5, the positions of a light guide 6 as well as of an observation window 7 which is viewable at the upper side of the apparatus 1 for an observer 8.

The light guide 6 carried by the holding device 2 trains a bundle of substantially parallel light rays 9 at a predetermined angle α upon the measuring window 5. The angle α can also vary slightly within the bundle of light rays 9, for example, by several degrees up to about $\pm$ 10°.

The light rays 10, reflected from each point of the measuring window 5 and, stated more precisely, said from the surface 3 of the article 4 at different angles β_1, β_2, etc., are collected by a light guide device 11 and are directed into the observation window 7 parallel or converging with and toward the observer 8. The light guide device 11 is carried by the holding device 2 and in the illustrated example is a collecting lens whose upper surface is formed with the observation window 7.

When the surface 3 of the article 4 carries, for example, an ink color layer which scatters light in an angle-dependent manner, the observer is offered a pattern of mutually adjacent color differences 13-16 which correspond to the reflected colors at the respective angles β_1, β_2, etc.

It will be apparent that for the measurement of the angle-dependent transmission behavior of a transparent or translucent article 4, the device 1 can be simply modified in that the light input guide 6 and the light guide 11 can be arranged on different sides of the measuring window 5. For example, the holding device 2 can have a corresponding opening in which the article 4 can be laid so that it lies between the light input guide 6 and the light guide 11. All previous and subsequent embodiments can be analogously configured also for transmission verification apparatuses.

The light input guide 6 can, as has been illustrated in FIG. 1, contain its own light source 17. Alternatively, the light input guide 6 can capture ambient light and direct it at the angle or angles α onto the measuring window 5. The light input guide 6 can thus supply white light as well as light with a predetermined amplitude profile in the wavelength range, for example, as a result of corresponding filtering of the ambient light, through the use of monochromatic or polychromatic light 17. In the illustrated case, the light source 17 is a white light producing light-emitting diodes.

The light guide device 11 can be a spherical collecting lens as well as a cylindrical collecting lens. The measuring window is located approximately in the region of the focal plane of the collecting lens, i.e., slightly ahead of the focal plane, in the focal plane or slightly behind the focal plane.

FIG. 2 shows an especially simply and compactly constructed apparatus 1. The light guide device 11 is here a

cylindrical collecting lens in the form of a semicylinder and the Figure shows a section taken axially normally through the cylinder. The measuring window 5 lies on the flat side of the semicylinder, the observation window 7 lies on own side of the curved upper side of the lens. The light feed 6 is a channel bored into the opposite side of the curved upper side and is positioned to capture ambient light at its inlet and trains it on the measuring window. The light feed 6 is thus directly embedded in the semicylindrical light guide device 11; in other words, the light guide device 11 simultaneously forms the holding device 2 for relative positioning of the light feed 6, the measuring window 5, the light guide device 11 and the observation window 7.

To exclude the influence of impeding ambient light, the semicylinder is provided with an opaque coating 18 except at the inlet mouth of the light feed 6, the measuring window 5 and the observation window 7 is provided with an opaque coating 18.

Instead of a light-feed channel, the light feed 6 can also be a light-emitting diode device embedded in the semicylinder or mounted on the semicylinder.

The measuring window 5 can also lie in, shortly ahead of or behind the focal plane of the cylindrical lens. When the latter is not a semicircle in section but rather has a circularly segmental form, i.e. the cylinder is not divided at the half but is divided outwardly of the center, the measuring window again can lie on the flat side so that the lens can be placed directly on the article.

The apparatus illustrated in FIGS. 3 and 4 serves to compare the angle-dependent reflection properties or transmission properties of a test object 4′ with a reference object 4" whereby both for the test object 4′ and for the reference object 4", a respective test device 1′ or 1" is provided. The devices 1′, 1" are disposed alongside one another and are connected together (see FIG. 4) whereby their observation windows 7 lie next to one another and with a quick glance, a comparison is made possible. Each of the devices 1′, 1" has, further, a light feed 6, a measuring window 5, a light-guide device 11 and an observation window 7.

In the embodiment of FIGS. 3 and 4, the light guide device 11 is formed from individual light conductors 19 which are oriented respectively at one of the angles β_1, β_2 or the like of the light beams 10 and capture these with their correspondingly oriented ends 20. The opposite ends 21 of the light wave guides 19 open at the upper side of the holding device 2, which is here configured in the form of a housing, at the observation window 7 or to form the observation window 7.

The device 1" has a receiver 22 fixed below the measuring window 5 for accommodating the reference object 4". This can be, in the illustrated example, a valid security [or piece of currency] and is wound onto a flattened drum 23 which can be laterally shifted into the receiver 22. The drum 23 can also be provided with a place for a number of different reference currencies 4" and can be rotatable so that the device can be switched between these reference currencies. The receiver 22 can, however, be configured for selective replacement of various reference objects.

The device 1" has a platform 24 on which the test article 4', for example, an article of currency, can be placed. For exact alignment of the test article 4', corresponding abutments 25 are provided on the platform 24.

FIG. 5 shows another embodiment of an apparatus having two devices 1', 1" connected together. The apparatus is comprised of a single continuous semicylindrical lens 11, similar to that of the embodiment of FIG. 2 and on which a light feed 6 with an integrated light source 6 is mounted. On the upper side of the semicylindrical lens 11 there are provided observation windows which need not be further delimited or framed. The apparatus can be placed on a platform 24 or can be fixed or articulated thereto at 26; abutments 25 are arranged on the platform 24 for positioning the test object 4' and the reference object 4".

Apart from the observation window 7 or observation windows 7, in each embodiment, scales, color scales or the like 27 can be provided. With the aid of such scales it is possible even with a single device 1 to make a comparison with predetermined setpoint or reference values.

In an embodiment, not shown, the observation window 7 can also be arranged to have a viewing screen on which the light rays 10 impinge after they have traversed the light guide device 11 and with which the diffusion effect of the viewing screen can supply an image readable from a number of directions. The light feed 6 must have a power capacity which suits this embodiment.

FIG. 6 shows an embodiment of an apparatus for the optical testing of flat objects, especially securities or currency

using a number of criteria. The apparatus encompasses a housing 30 which offers the user a substantially horizontal placement surface 31 on which flat objects (not shown), can be laid. The placement surface 31 is overlain by a part of the housing 30 in the form of an cover hood 32, whereby the cover hood 32 enables access to the placement surface 31 through an opening directed to the front.

The placement surface 31 encompasses a number of regions 33-36 (signified by broken lines in the drawing) on which an object (not illustrated) can be supported or can be deposited. The emplacement surface 31 is connected to or flush with a region 33-36 adjacent it so that an object can be simply shifted between the region 33-36 back and forth. The regions 31-36 need not necessarily be located adjacent one another but can also partly or wholly overlap and as to that there are certain preferences which will be detailed subsequently.

Over the first region 33 a device 1 is supported by the housing 30 such that its measuring window 5 is disposed above a first region 33 or coincides with it. The device 1 can be constructed as has previously been illustrated in connection with FIGS. 1-5 (also complete units according to FIGS. 3-5 are possible) and is thus not shown with the exception of its observation window 7. When the device 1 tests the transmission scattering properties, it is in part arranged below the emplacement surface 31, i.e. the emplacement surface 31 or the first region 33 extends into the device 1.

The housing 30 carries an infrared camera 37 which is trained on the second region 34 of the emplacement surface 31. The

infrared camera 37 is a commercial black-white CCD camera which is provided with a blocking filter 38 for filtering out the possible light range.

The filter curve of the blocking filter 36 is illustrated in FIG. 7. FIG. 7 shows the relative light power transmission in percent, normalized with respect to air, i.e. 100% corresponding to the transmission through air, versus the wavelength in nm. It is apparent that in the visible light range (380-760 nm), the transmission amounts to substantially 0% and in the infrared range sharply increases.

The output signal of the infrared camera 37 can be available at the output connector 39 of the housing 30 for connection to an external monitor (not shown). Alternatively, or additionally, the housing 30 carries in itself a small monitor 40 of the LCD type.

In the housing 30, a "second" light source 41 is arranged which is trained on the second region 34 and has a significant proportion of its radiation in infrared. (The "first" light source is such that it itself is arranged in the device 1.) Especially suitable are commercially available inexpensive glow filament lamps which have a large infrared proportion.

By means of the infrared camera 37 with the aid of ambient light or the light source 41, an infrared reflection image of an image in the region 34 can be produced and, for example, can be displayed on the monitor 40.

The emplacement surface 31 can be constructed so that it is light permeable in the second range 34, for example by the flush

insertion of a glass pane as has been indicated at 42. Beneath the glass pane 32 a third light source 43 is arranged in the housing 30 and has a significant radiation component in the infrared range and again preferably is formed by a glow film lamp. When the third light source 43 is turned on, an infrared transmission image of the object in the region 34 can be produced by the infrared camera.

The light source 43 in the form of a glow lamp also has a significant radiation component in the visible light range. When the light 34 is turned on, a transmission image visible with the free eyes can be obtained from an object.

The control of the second or third light sources 41, 43 is so carried out that respectively only one of the two light sources is turned on.

In a rearward portion of the cover hood 32, i.e. spaced as far as possible from the opening, a third region of the emplacement surface 31 is formed. Above the third region 35 a fourth light source 45 is arranged which has a significant radiation component in the ultraviolet range. The fourth light source 45 is covered by a shielding plate 46 to prevent a direct view by the observer of the light source 45.

This arrangement enables the excitation of the fluorescent inks (UV converters) of objects to be observed with the free eye.

The fourth light source 40 is preferably a gas-discharge lamp. Such lamps require a certain time for turning on. To avoid the waiting periods in operation, the fourth light source 45 can be continuously switched on. This means that the third region 45

should be spaced by a certain distance from the second region 34 so that image distortions of the infrared camera having their origins in flicker effects of the gas-discharge lamp, should the regions 34 and 35 overlap, can be avoided.

The fourth region 36 is formed on the emplacement surface 36, in addition, and is equipped with an inductive sensor. With the aid of this sensor, the presence and optionally also the arrangement of inks with magnetic or metallic particles can be detected. Signal lights 47 are turned on by the induction sensor of the region 36 to render the sensor results optically effective. The sensor measurements can also be displayed on the monitor 40 or also with the aid of an acoustic signal.

The testing evaluating devices associated with the regions 33-36 can remain continuously in operation after the apparatus has been turned on (independently of the condition that the light sources 41 and 43 are to operate only alternatively) or the individual devices can be set in operation sequentially (independently of the preference that the ultraviolet source 45 should remain continuously in operation). To simplify the operation as much as possible, a single button 48 can, for example, be used which will trigger these control functions and/or a rotary selection switch 49 may be amplified.

The aforedescribed devices and apparatuses can be used for all kinds of objects and reflections or transmission-scattering subjects and thus for example also for cinegrams, surface-lighted holograms and transmission-lighted holograms or the like. It is also possible to further evaluate images which appear in the

observation window automatically or mechanically, for example by capturing an image with a photographic camera for processing the image with the aid of a CCD camera and associated image transmission, image evaluation, image processing and image archiving processes which are known in the art. Such further processing is also possible for the output signal of the infrared camera.